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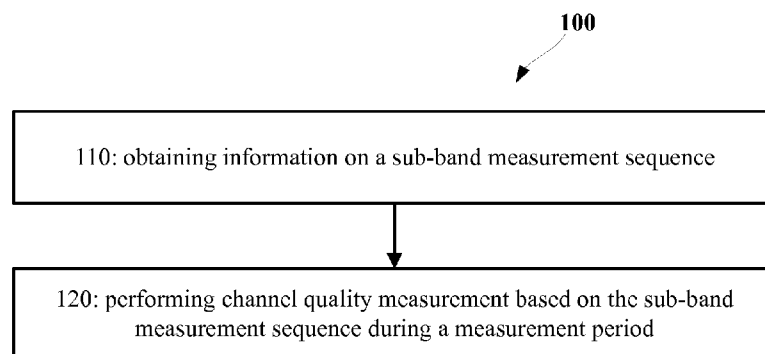


Fig. 1

(57) Abstract: The present disclosure provides a method and apparatus for channel quality measurement for an MTC UE, wherein the method performed at the MTC UE comprises: obtaining information on a sub-band measurement sequence of a plurality of sub-bands for which channel quality measurement is to be performed by the MTC UE; and during a measurement period, performing channel quality measurement on the plurality of sub-bands based on the sub-band measurement sequence.



METHOD AND APPARATUS FOR CHANNEL QUALITY MEASUREMENT FOR MTC UE**FIELD OF THE INVENTION**

[0001] The present disclosure generally relates to the field of wireless communications, and more specifically relates to a method and apparatus for channel quality measurement for an MTC UE.

BACKGROUND OF THE INVENTION

[0002] A machine type communication (MTC) user equipment (UE) is a machine-specific UE. In 3GPP R12, a Work Item on Low Complexity MTC (LC-MTC) UE is concluded where the complexity (cost) of the MTC UE is reduced by approximately 50%. In Rel-13, another Work Item is agreed to further reduce the complexity of the MTC UE, to enhance the coverage and reduce power consumption of the MTC UE. A main complexity reduction technique is to reduce the radio-frequency bandwidth of the LC-MTC UE to 1.4 MHz (i.e., operating in 6 Physical Resource Blocks (PRBs) (where PRB is a unit of resource allocation in the frequency domain)). LC-MTC UEs are expected to operate in any system bandwidth and shall be able to co-exist with legacy UEs. It is also expected that LC-MTC UEs can retune their frequency to operate in different (1.4 MHz, for example) sub-bands within the (larger) system bandwidth to allow frequency multiplexing among LC-MTC UEs and among LC-MTC UEs and legacy UEs.

[0003] It is understood that frequency channel dependent scheduling can bring great gains, and hence during the discussing in 3GPP RAN1 meeting, most companies support Channel Status Information (CSI) report in normal coverage mode. However, the low complexity MTC UE can only measure the narrow band as wide as 6PRBs, and after completion of one measurement, it needs at most one sub-frame to switch to another sub-band it needs to measure. So the measurement procedure should be quite different from a normal UE. Here, the Channel Quality Information (CQI) report procedure of a normal UE may be briefly described as follows:

[0004] The CQI report can be configured in radio resource control (RRC) messages, e.g., a RRCConnectionSetup message (i.e., msg4), a RRCConnectionReestablishment message and a RRCConnectionReconfiguration message.

[0005] In the current standards, a base station (eNB) may configure the UE to perform channel condition reporting, including one of the three types:

[0006] Option 1: Wideband reporting

[0007] Option 2: eNB configured sub-band reporting

[0008] Option 3: UE selected sub-band reporting

[0009] A Non-MIMO operation will not use wideband reporting (option 1). Since a LC-MTC UE generally has only single antenna due to cost consideration, it will therefore not be configured for wideband reporting. Hence, the LC-MTC UE may consider using the eNB configured sub-band reporting (option 2) or UE selected sub-band reporting (option 3).

[0010] For eNB configured sub-band reporting (option 2), the sub-band sizes are 4~8 PRBs depending on the system bandwidth. The UE reports a wideband CQI and a few sub-band CQI values designated by the eNB. The CQI for each sub-band is encoded in 2 bits, representing the differential to the wideband CQI. For UE selected sub-band reporting (option 3), the UE selects M best sub-bands (where M depends on the system bandwidth), calculates one average CQI value and reports the average CQI value (in a form of the differential to the wideband CQI) and the

selected sub-bands to the eNB. Periodic CQI report uses PUCCH, while aperiodic CQI report is carried by PUSCH.

SUMMARY OF THE INVENTION

[0011] However, the current channel quality measurement scheme for a normal UE is not suitable for LC-MTC UEs due to the following reasons:

[0012] 1. The LC-MTC UE only has a single antenna and cannot measure wide band CQI which is required by all of the measurement options.

[0013] 2. The measured sub-band exceeds 6PRBs. If a sub-band is defined to have 6PRBs, the number of sub-bands will exceed the current definition.

[0014] 3. The LC-MTC UE can only provide the measurement result of one subband for each measurement.

[0015] 4. The LC-MTC UE only supports a few transmission modes, so the measurement control could be much simplified.

[0016] 5. The LC-MTC UE needs to consider coverage enhancement, while the current measurement procedure does not consider it.

[0017] Besides, LC-MTC UE is usually assumed to be stationary, so infrequent channel quality measurement would be enough. Next, the LC-MTC UE needs to switch to another frequency to perform measurement after one sub-band measurement is completed. This procedure is more complex than that for a normal UE, so the measurement procedure needs to be carefully designed to avoid any unnecessary measurements. Hence, aperiodic measurement is focused in the present disclosure, i.e. measurement is only done performed when necessary.

[0018] Therefore, it may be seen that the channel quality measurement for the LC-MTC UE cannot directly use a traditional measurement procedure for a normal UE; instead, it needs to be re-designed. However, currently there is no mature solution yet specifically for the channel quality measurement for the LC-MTC UE.

[0019] In view of the above problems, the present disclosure provides a method and apparatus for channel quality measurement for an MTC UE (more specifically, Low Complexity MTC UE).

[0020] According to a first aspect of the present disclosure, there is provided a method for channel quality measurement for an MTC UE, the method being performed at the MTC UE comprising: obtaining information on a sub-band measurement sequence of a plurality of sub-bands for which the channel quality measurement is to be performed by the MTC UE; and during a measurement period, performing the channel quality measurement on the plurality of sub-bands based on the sub-band measurement sequence.

[0021] According to another aspect of the present disclosure, there is provided an apparatus for channel quality measurement for an MTC UE, the apparatus being in the MTC UE, comprising: an obtaining unit configured to obtain information on a sub-band measurement sequence of a plurality of sub-bands for which the channel quality measurement is to be performed by the MTC UE; and a measuring unit configured to perform, during a measurement period, the channel quality measurement on the plurality of sub-bands based on the sub-band measurement sequence.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] The present disclosure will be better understood and other objectives, details, features and advantages of the present disclosure will become more obvious after reading the depiction of the preferred embodiments of the present disclosure with reference to the accompanying drawings. In the accompanying drawings,

[0023] Fig. 1 illustrates a flow diagram of a method for channel quality measurement for an MTC UE according to the embodiments of the present disclosure;

[0024] Fig. 2 illustrates a schematic diagram of an apparatus for channel quality measurement for an MTC UE according to the embodiments of the present disclosure; and

[0025] Fig. 3 illustrates a simulation diagram of the channel quality measurement scheme according to the present disclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] Hereinafter, the preferred embodiments of the present disclosure will be described in more detail with reference to the accompanying drawings. Although the accompanying drawings show the preferred embodiments of the present disclosure, it should be noted that the present disclosure may be implemented in various manners, not limited to the embodiments illustrated here. Instead, these embodiments are provided to make the present disclosure more thorough and complete so as to be capable of conveying the scope of the present disclosure completely to those skilled in the art.

[0027] LC-MTC traffic is featured by small data volume but a large connection scope. Therefore, the eNB generally does not schedule a specific LC-MTC UE to other sub-bands, because one LC-MTC UE will not bring too heavy burden. Through inter-UE multiplexing, each sub-band can be well balanced. Therefore, it is possible to combine the eNB-configured channel quality measurement and the UE-configured channel quality measurement into one option. This will make the configuration much simpler and reduce the overheads.

[0028] A basic idea of the present disclosure is to define a sub-band measurement sequence for LC-MTC UEs in the normal mode and the coverage enhancement mode. The eNB initiates a measurement period for the MTC UE. During the measurement period, the MTC UE executes channel measurements (e.g., CQI measurements or reference signal received power (RSRP) measurements) for a predetermined number of sub-bands according to the sub-band measurement sequence.

[0029] Fig. 1 illustrates a flow diagram of a method 100 for channel quality measurement for an MTC UE according to embodiments of the present disclosure, wherein the method 100 is implemented in the MTC UE or implemented by the MTC UE.

[0030] As illustrated in Fig. 1, in step 110, the MTC UE obtains information on a sub-band measurement sequence of one or more sub-bands for which channel quality measurement is to be performed.

[0031] In one implementation, the sub-band measurement sequence is designated by a serving base station (eNB) of the MTC UE.

[0032] For example, the sub-band measurement sequence may be indicated by the serving base station to the MTC UE via a system message. One instance of such sequence is a *golden* sequence.

[0033] Besides, the sub-band measurement sequence may also be defined in a system specification.

[0034] In another implementation, the sub-band measurement sequence may be derived by the MTC UE based on a specific function relationship.

[0035] For example, a function relationship about a sub-band measurement sequence may be indicated by the base station through a system message or prescribed in a system specification. The MTC UE can derive the sub-band measurement sequence based on the function relationship.

[0036] The sub-band measurement sequence is configured such that the next sub-band to be measured is a sub-band with a maximum sum of squared frequency distance to previously measured N sub-bands. For example, if there are sub-bands $\{S_1, S_2, S_3, \dots, S_k\}$ and the current occupied and previous measured sub-bands are S_n and S_m , respectively, then the next sub-band S_i to be measured is determined by the following equation (1):

$$[0037] \quad \text{maximize}(\sqrt{(s_i - s_m)^2 + (s_i - s_n)^2}) \quad (1)$$

where S_i belongs to the set $\{S_1, S_2, S_{m-1}, S_{m+1}, \dots, S_{n-1}, S_{n+1}, \dots, S_k\}$, and $N=2$.

[0038] The above manner of determining the sub-band measuring sequence ensures that the measured sub-bands in consecutive reports are as uncorrelated as possible, wherein N is specified by the base station.

[0039] Next, in step 120, during a measurement period, the MTC UE performs channel quality measurement on the one or more sub-bands based on the obtained sub-band measurement sequence.

[0040] The channel quality measurement of the sub-band may be initiated through an evolved physical downlink control channel (EPDCCH). When the sub-band measurement sequence is opened for a period of time (e.g., measurement period), the eNB may request the MTC UE to perform these radio resource management (RRM) measurements. The MTC UE will perform measurement during the measurement period and provide a measurement report as required or provide a measurement report if the measurement result triggers some pre-configured measurement events.

[0041] In one implementation, the MTC UE also receives, from the serving base station of the MTC UE, indication information indicating the number of sub-bands to be measured, and performs channel quality measurement on the indicated number of sub-bands during the measurement period.

[0042] Because the MTC UE is generally stationary, the eNB may initiate measurement when the measured channel fading variation becomes negative, for example. In this case, the number of sub-bands to be measured, for example, may be determined by the equation (2) below:

$$[0043] \quad \text{Min}(\text{Max}(1, -W), N_s - 1) \quad (2),$$

where N_s is the total number of MTC sub-bands, and W is the measured channel fading variation. The sequence of the sub-bands to be measured is determined by the sub-band measurement sequence.

[0044] In one implementation, the MTC UE may perform a downlink channel quality measurement by measuring a demodulation reference signal (DMRS) transmitted by the base station.

[0045] In one implementation, based on the configuration of eNB, the sub-band measurement sequence may only include a subset of the sub-bands of the system bandwidth. This is to avoid certain sub-bands to be heavily utilized by normal UEs (e.g. PRBs used for EPDCCH for legacy UE), for example.

[0046] Furthermore, the method 100 may also comprise: when the MTC UE is in a coverage

enhancement mode, for each sub-band to be measured, the channel quality measurement for the sub-band is repetitively performed in multiple sub-frames.

[0047] This idea is suitable for layer 1 measurement, e.g., CSI, and is also suitable for radio resource control (RRC) measurement, e.g., RSRP.

[0048] In one implementation, the eNB may indicate a duration of the measurement period by which the UE can derive how many measurements it needs to perform. Alternatively, the number of measurements may also be indicated directly by the eNB. This can be semi-stationary configured through higher layer signaling or dedicated signaling, or indicated in EPDCCH to enable dynamic configuration.

[0049] In another implementation, the number of repetitions may be determined by the MTC UE according to a preset coverage enhancement level. The MTC UE should measure as many as possible sub-bands in the measurement period.

[0050] Moreover, when the number of repetitions of the channel quality measurement exceeds a predetermined threshold, the MTC UE will automatically suspend measurement. This is to avoid LC-MTC UE in deep coverage from wasting power in performing multiple sub-band measurements.

[0051] For the coverage enhancement mode, according to one implementation, the base station may also configure a time threshold to the MTC UE, such that when the time elapsed after the MTC UE enters into the coverage enhancement mode reaches the time threshold, the channel quality information previously measured by the MTC UE will not be used any longer.

[0052] In the method 100, in one implementation, the measurement period may be associated with data transmission of the MTC UE. For example, measurement may be started from an end of each frequency hopping transmission of the MTC UE. The base station may make some or all of the measured sub-bands overlap with a frequency hopping pattern, so as to complete the channel quality measurement while performing frequency hopping transmission.

[0053] In another implementation, the measurement period may not be associated with data transmission. In other words, during the measurement period, the MTC UE does not perform any data transmission.

[0054] In yet another implementation, the eNB may also transmit EPDCCH/PDSCH in the sub-bands where the MTC UE performs measurement. This is possible since the eNB knows exactly which sub-band the LC-MTC UE is measuring.

[0055] Furthermore, the MTC UE might not perform periodic measurement; instead, it performs channel quality measurement on the sub-band where a system paging message is located when receiving the system paging message.

[0056] Furthermore, the MTC UE may perform channel quality measurement in advance before performing channel access, and report the measured channel quality information to the base station during the access process or at the end of the channel quality measurement.

[0057] Further, the method 100 also comprises: reporting, by the MTC UE, channel quality information of each sub-band or best sub-band to the serving base station according to a result of channel quality measurement.

[0058] In this case, when there is no sub-band better than the current sub-band, the MTC UE might not report any channel quality information either.

[0059] In another implementation, the base station may configure a predetermined threshold for the MTC UE such that only when the measured quality of a sub-band is not lower than the

predetermined threshold, the MTC UE will report the measured channel quality information to the base station.

[0060] In the present disclosure, the channel quality information is a difference between channel quality of the measured sub-band and that of the current sub-band or a difference between channel quality of the measured sub-band and that of a last measured sub-band, unlike the wideband CQI in current specification 3GPP TS 23.213.

[0061] Furthermore, in one implementation, the size of each measured sub-band corresponds to the MTC sub-band definition. In other words, the size of the measured sub-band may be determined based on the MTC sub-band definition. In this manner, an association is established between the size of the measured sub-band and the MTC sub-band definition, without a need of explicitly indicating the size of the measured sub-band (this is different from sub-band measurement for 4-8 PRBs of a normal UE).

[0062] Furthermore, based on the design of the present disclosure, a request from the eNB may be used for triggering multiple MTC UEs to perform channel quality measurement. This may be implemented by transmitting a common measurement configuration in the system message or via an EPDCCH with a common RNTI. Upon receiving this request, each MTC UE will start a one-off measurement.

[0063] A downlink quality measurement solution from the base station to the MTC UE has been described above. On the other hand, for an uplink channel quality measurement, the base station may request the MTC UE to transmit a higher-layer signaling (e.g., layer 2 or layer 3 signaling) to the base station such that the base station can perform uplink channel quality measurement according to the reference signal in the physical channel that carries the higher-layer signaling.

[0064] Fig. 2 illustrates a schematic diagram of an apparatus 200 for channel quality measurement for an MTC UE according to the embodiments of the present disclosure. The apparatus 200 is in the MTC UE or implemented by the MTC UE, for example.

[0065] As illustrated in Fig. 2, the apparatus 200 comprises an obtaining unit 210 configured to obtain information on a sub-band measurement sequence of a plurality of sub-bands for which channel quality measurement is to be performed by the MTC UE; and a measuring unit 220 configured to perform, during a measurement period, channel quality measurement on the plurality of sub-bands based on the sub-band measurement sequence.

[0066] In one implementation, the sub-band measurement sequence is designated by a serving base station of the MTC UE or derived according to a specific function relationship.

[0067] In one implementation, the sub-band measurement sequence is configured such that the next sub-band to be measured is a sub-band with a maximum sum of squared frequency distance to previously measured sub-bands.

[0068] In one implementation, the apparatus 200 further comprises a receiving unit 230 configured to receive, from the serving base station of the MTC UE, indication information indicating the number of sub-bands to be measured, and the measuring unit 220 performs channel quality measurement on the indicated number of sub-bands during the measurement period.

[0069] In one implementation, when the MTC UE is in a coverage enhancement mode, for each sub-band to be measured, the measurement unit 220 repetitively performs the channel quality measurement for the sub-band in multiple sub-frames.

[0070] In one implementation, the number of repetitions of performing the channel quality measurement of the sub-band is indicated by the serving base station of the MTC UE or determined by the MTC UE according to a preset coverage enhancement level.

[0071] In one implementation, when the indicated or determined number of repetitions exceeds a predetermined threshold, the MTC UE may suspend channel quality measurement.

[0072] In one implementation, the measurement period may be associated with the data transmission period of the MTC UE.

[0073] In one implementation, during the measurement period, the MTC UE does not perform any data transmission.

[0074] In one implementation, the apparatus 200 further comprises a transmitting unit 240 configured to report channel quality information of each sub-band or best sub-band in the plurality of sub-bands to the serving base station of the MTC UE according to result of channel quality measurement.

[0075] In one implementation, the size of each sub-band in the plurality of sub-bands corresponds to the MTC sub-band definition.

[0076] Hereinafter, a specific example of the above solution will be provided.

[0077] Suppose that the LC-MTC UE works in a normal coverage mode. It has 17 sub-bands in total, while the current sub-band is 10. The eNB configures to measure 2 sub-bands in each measurement period, and the UE measures one sub-frame of each sub-band. The sub-band measurement sequence is *golden* sequence. The shift is UE specific, i.e., determined by the UE's common radio network temporary identifier (RNTI) and counted through the number of sub-frames.

[0078] Suppose that in a sub-frame (denoted as sub-frame N), the eNB indicates the LC-MTC UE via EPDCCH to report CSI, then the LC-MTC UE calculates that the sub-bands to be measured are sub-band 2 and 15 for example according to a *golden* sequence.

[0079] In sub-frame N+1, the LC-MTC UE switches to sub-band 2, and in sub-frame N+2, it measures the channel quality of sub-band 2.

[0080] In sub-frame N+3, the LC-MTC UE switches to sub-band 15, and in sub-frame N+4, it measures the channel quality of sub-band 15.

[0081] In sub-frame N+5, it switches back to current sub-band 10, and reports CSI in sub-frame N+6. Hence, the resources allocated for the PUSCH is sub-frame N+6. This is different from current UE behavior.

[0082] The CSI measurement report in this example is:

CQI value of sub-band 2
CQI value of sub-band 15

[0083] The CQI value is defined by the difference between the measured sub-band and the current sub-band, as shown in the table below:

Encoded bits for CQI	Offset value (dB)
00	≤ 1
01	2
10	3
11	≥ 4

[0084] The eNB may then choose between the measured sub-band and the current sub-band, and instruct the MTC UE to switch to the better sub-band.

[0085] Fig. 3 illustrates a simulation diagram of the channel quality measurement solution according to the present disclosure.

[0086] In the simulation, performance of the suggested channel quality measurement solution is evaluated based on a sub-band selection instance. Suppose that the system bandwidth is 20 MHz, configured with 16 sub-bands, and measurement is performed once every 50ms. The number of sub-bands to be measured is determined according to equation (2) above. The simulation result is shown in Fig. 3, which illustrates the channel fading situation as experienced. The initial sub-band is sub-band 1, and its channel condition is shown by the curve at the bottom of Fig. 3. It may be seen that deep fading appear for two times. However, the suggested solution can effectively avoid this phenomenon. Moreover, in most time, it shows a higher gain than a solution without sub-band selection.

[0087] The solution according to the present disclosure can support narrow-band MTC UE (particularly LC-MTC UE) to measure different sub-bands. This is very helpful for scheduling according to frequency. Compared with the conventional solution, the suggested solution is more effective with lower overheads.

[0088] In one or more exemplary designs, functions of the present application may be implemented by hardware, software, firmware, or any combination thereof. In the case of being implemented by software, the functions may be stored on a computer-readable medium as one or more instructions or codes, or transmitted as one or more instructions or codes on the computer-readable medium. The computer-readable medium includes a computer storage medium and a communication medium, wherein the communication medium includes any medium facilitating the computer program to be delivered from one place to another place. The storage medium may be any available medium that is accessible to a general or dedicated computer. Such computer-readable medium may include, for example, but not limited to, RAM, ROM, EEPROM, CD-ROM or other optical disk storage device, magnetic disk storage device, or other magnetic storage device, or any other medium available for carrying or storing desired program code modules in a form of instructions or data structure that is accessible by a general or dedicated computer or by a general or dedicated processor. Moreover, any connection may also be referred to as a computer readable medium. For example, if software is transmitted from a website, a server or other remote source using a co-axial cable, an optical fiber cable, a twisted pair cable, a digital subscriber line (DSL) or radio technologies such as infrared, radio, microwave and the like, then the co-axial cable, optical fiber cable, twisted pair cable, digital subscriber line (DSL) or radio technologies such as infrared, radio, microwave and the like are also included in the definition of the medium.

[0089] Various kinds of exemplary logical blocks, modules and circuits as described in conjunction with the present disclosure may be implemented or executed using a general processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, a discrete gate, or a transistor logic, discrete hardware components, or any combinations thereof for performing the functions of the present disclosure. The general-purpose processor may be a microprocessor; or, the processor may also be any common processor, controller, micro-controller or state machine. The processor may also be implemented as a combination of computing devices, e.g., a

combination of DSP and microprocessor, a combination of microprocessors, or a combination of one or more microprocessors and DSP kernel, or any other kind of such structure.

[0090] A person of normal skill in the art should understand that various kinds of exemplary logic blocks, modules, circuits and algorithm steps described in conjunction with the embodiments of the present application may also be implemented as electronic hardware, computer software or a combination thereof. In order to clearly illustrate such exchangeability between hardware and software, various exemplary components, blocks, modules, circuits, and steps have been described above in general around their functions. As to whether this function is implemented in hardware or software, it depends on a specific application and a design constraint condition applied onto the entire system. Those skilled in the art may implement the described functions in a flexible manner for each specific application. However, such implementation decision should not be construed as departing from the protection scope of the present disclosure.

[0091] The description above of the present disclosure is to enable any person of normal skill in the art to implement or use the present disclosure. For a person of normal skill in the art, various modifications of the present disclosure are obvious; moreover, a general principle of the definition herein may also be applied to other variations without departing from the spirit and protection scope of the present disclosure. Therefore, the present disclosure is not limited to the instances and design as described here; instead, it is consistent with the broadest scope of the principle and novelty features of the present disclosure.

Claims

1. A method for channel quality measurement for an MTC UE, the method being performed at the MTC UE, the method comprising:
 - obtaining information on a sub-band measurement sequence of a plurality of sub-bands for which the channel quality measurement is to be performed by the MTC UE; and
 - during a measurement period, performing the channel quality measurement on the plurality of sub-bands based on the sub-band measurement sequence.
2. The method according to claim 1, wherein the sub-band measurement sequence is designated by a serving base station of the MTC UE or derived according to a specific function relationship.
3. The method according to claim 1, wherein the sub-band measurement sequence is configured such that a next sub-band to be measured is a sub-band with a maximum sum of squared frequency distance to previously measured sub-bands.
4. The method according to claim 1, further comprising:
 - receiving, from the serving base station of the MTC UE, indication information indicating the number of sub-bands to be measured, and
 - during the measurement period, performing channel quality measurement on the indicated number of sub-bands.
5. The method according to claim 1, wherein when the MTC UE is in a coverage enhancement mode, the method further comprises:
 - for each sub-band to be measured, repetitively performing the channel quality measurement for the sub-band in multiple sub-frames.
6. The method according to claim 5, wherein a number of repetitions of performing the channel quality measurement of the sub-band is indicated by the serving base station of the MTC UE or determined by the MTC UE according to a preset coverage enhancement level.
7. The method according to claim 6, further comprising:
 - when the indicated or determined number of repetitions of the channel quality measurement exceeds a predetermined threshold, suspending the channel quality measurement.
8. The method according to claim 1, wherein the measurement period is associated with a data transmission period of the MTC UE.
9. The method according to claim 1, wherein, during the measurement period, the MTC UE does not perform any data transmission.
10. The method according to claim 1, further comprising:
 - reporting channel quality information of each sub-band or best sub-band in the plurality of sub-bands to the serving base station of the MTC UE according to result of the channel quality

measurement.

11. The method according to claim 1, wherein size of each sub-band in the plurality of sub-bands corresponds to an MTC sub-band definition.

12. An apparatus for channel quality measurement for an MTC UE, the apparatus being in the MTC UE, the apparatus comprising:

an obtaining unit configured to obtain information on a sub-band measurement sequence of a plurality of sub-bands for which the channel quality measurement is to be performed by the MTC UE; and

a measuring unit configured to perform, during a measurement period, the channel quality measurement on the plurality of sub-bands based on the sub-band measurement sequence.

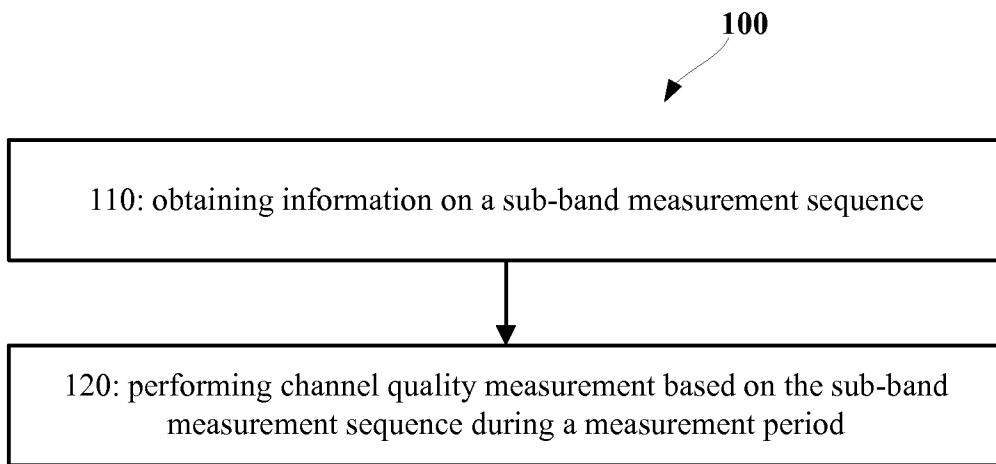
13. The apparatus according to claim 12, wherein the sub-band measurement sequence is configured such that a next sub-band to be measured is a sub-band with a maximum sum of squared frequency distance to previously measured sub-bands.

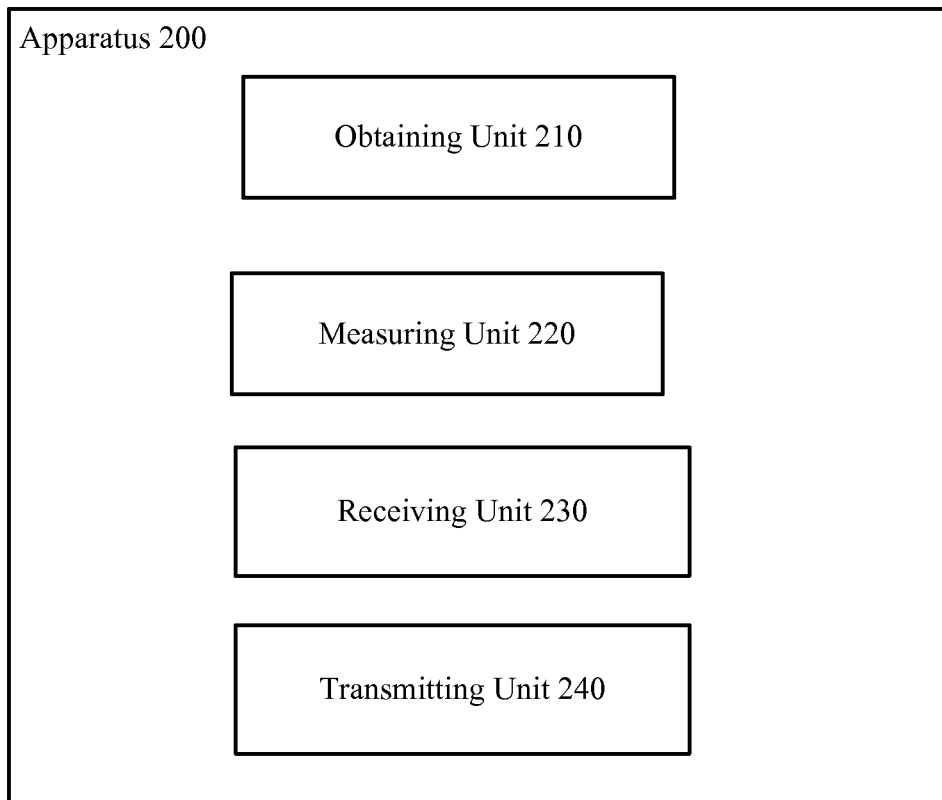
14. The apparatus according to claim 12, further comprising:

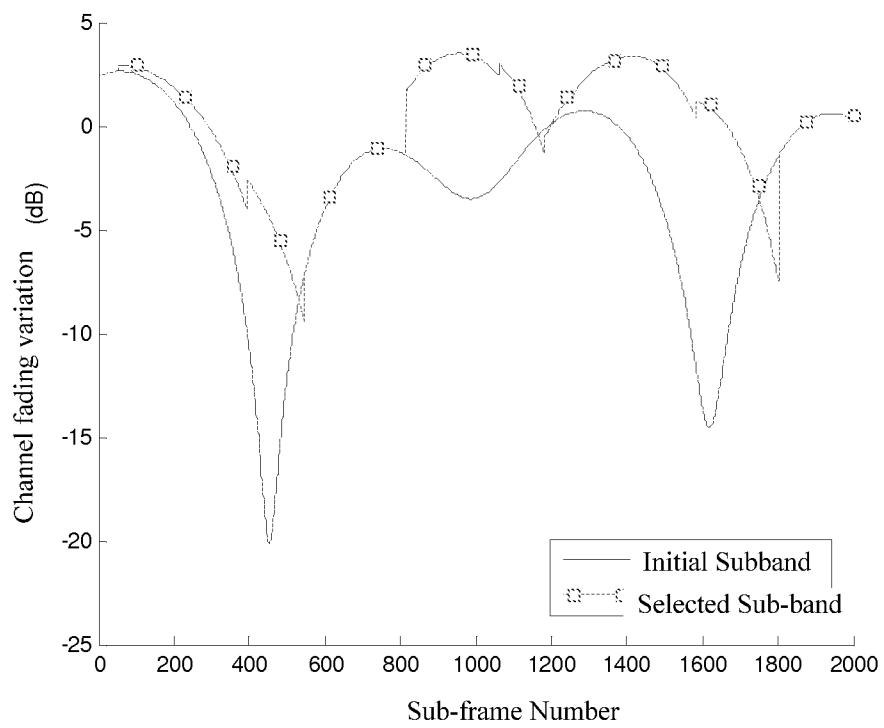
a receiving unit configured to receive, from the serving base station of the MTC UE, indication information indicating the number of sub-bands to be measured, and

wherein the measuring unit performs channel quality measurement on the indicated number of sub-bands during the measurement period.

15. The apparatus according to claim 12, wherein when the MTC UE is in a coverage enhancement mode, for each sub-band to be measured, the measurement unit repetitively performs the channel quality measurement for the sub-band in multiple sub-frames.

**Fig. 1**

**Fig. 2**

**Fig. 3**

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2016/000768

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L1/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2015/062887 A2 (SONY CORP [JP]; SONY EUROPE LTD [GB]) 7 May 2015 (2015-05-07) abstract page 1, line 23 - line 35 page 4, line 7 - page 5, line 7 page 9, line 27 - page 10, line 18 page 13, line 9 - page 18, line 16 ----- -/--	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search

3 August 2016

Date of mailing of the international search report

10/08/2016

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INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2016/000768

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NTT DOCOMO: "Remaining issues on PDSCH for low complexity MTC", 3GPP DRAFT; R1-152053 PDSCH, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Belgrade, Serbia; 20150420 - 20150424 19 April 2015 (2015-04-19), XP050934902, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_ SYNC/RAN1/Docs/ [retrieved on 2015-04-19] * section 2 * -----	1-15
X	WO 2015/012653 A1 (LG ELECTRONICS INC [KR]) 29 January 2015 (2015-01-29) abstract page 2, paragraph 9 - paragraph 10 -----	1,12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2016/000768

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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WO 2015012653 A1	29-01-2015	CN 105340316 A US 2016182208 A1 WO 2015012653 A1	17-02-2016 23-06-2016 29-01-2015